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o certify that the attached copy of the request for grant of a Patent (Form 1/77) bears an dment, effected by this office, following a request by the applicant and agreed to by the ptroller-General.

In ordance with the Patents (Companies Re-registration) Rules 1982, if a company named in certificate and any accompanying documents has re-registered under the Companies Act 19 with the same name as that with which it was registered immediately before re-reg tion save for the substitution as, or inclusion as, the last part of the name of the words "pu limited company" or their equivalents in Welsh, references to the name of the company in th rtificate and any accompanying documents shall be treated as references to the name with ch it is so re-registered.

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THE PATENT OFFICE
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CT99 E486677-1 C06256
F01/7700 0.00 - 9925164.7

# Request for grant of a patent

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|---|---|---|
| 1. | Your reference | P/62128 |

| | | | |
|---|---|---|---|
| 2. | Patent application number *(The Patent Office will fill in this part)* | 26 OCT 1999 | **9925164.7** |

3. Full name, address and postcode of the or of each applicant *(underline all surnames)*

**Marconi Communications Limited**
**New Century Park**
**P O Box 53**
**Coventry CV3 1HJ**

Patents ADP number *(if you know it)*
If the applicant is a corporate body, give the country/state of its incorporation

**ENGLAND**

7579 200001

4. Title of the invention

**Communications System**

5. Name of your agent *(if you have one)*

~~G COCKAYNE~~  C F HOSTE .

"Address for service" in the United Kingdom to which all correspondence should be sent

*(including the postcode)*
Patents ADP number *(if you know it)*

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51 77
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| | | Country | Priority application number *(if you know it)* | Date of filing *(day / month / year)* |
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| 6. | If you are declaring priority from one or more earlier patent applications, give the country and the date of filing of the or of each of these earlier applications and *(if you know it)* the or each application number | | | |

| | | Number of earlier application | Date of filing *(day / month / year)* |
|---|---|---|---|
| 7. | If this application is divided or otherwise derived from an earlier UK application, give the number and the filing date of the earlier application | | |

8. Is a statement of inventorship and of right to grant of a patent required in support of this request? *(Answer 'Yes' if:*
a) *any applicant named in part 3 is not an inventor, or*
b) *there is an inventor who is not named as an applicant, or*
c) *any named applicant is a corporate body*
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| Description | **11** |
| Claim(s) | **3** |
| Abstract | **1** |
| Drawing(s) | **4** |

10. If you are also filing any of the following,
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| Priority documents | |
| Translations of priority documents | — |
| Statement of inventorship and right to grant of a patent (Patents Form 7/77) | — |
| Request for preliminary examination and search (Patents Form 9/77) | — |
| Request for substantive examination (Patents Form 10/77) | — |
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11.     I/We request the grant of a patent on the basis of this application.

Signature

**G   COCKAYNE**

Date
25.10.99

12. Name and daytime telephone number of
    person to contact in the United Kingdom     **A P Cardus**     **01245 275124**

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## Statement of inventorship and of right to grant of a patent

The Patent Office

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|---|---|---|
| 1. | Your reference | P/62128.GBA |
| 2. | Patent application number *(if you know it)* | 9925164.7 D3. |
| 3. | Full name of the or of each applicant | MARCONI COMMUNICATIONS LIMITED |
| 4. | Title of the invention | COMMUNICATIONS SYSTEM |
| 5. | State how the applicant*(s)* derived the right from the inventor*(s)* to be granted a patent | By virtue of Section 39(1) of the 1977 Patents Act |
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7.

I/We believe that the person*(s)* named over the page *(and on any extra copies of this form)* is/are the inventor*(s)* of the invention which the above patent application relates to.

Signature

C F HOSTE

Date

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A P CARDUS

01245 275124

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## COMMUNICATIONS SYSTEM

The present invention relates to the field of synchronous hierarchy communications

networks, for example synchronous digital hierarchy (SDH) and SONET networks and

to the synchronisation of network elements within such networks.


A synchronous hierarchy communications network comprises a number of interconnected

nodes or network elements (NE), e.g. SDH equipment (SE), arranged to exchange data,

synchronisation and control signalling according to a synchronous hierarchy, as set out

for example in the synchronous digital hierarchy (SDH) or SONET standards. Typically

a synchronisation signal will be passed from one NE to the next, along with the data

signal, so creating a synchronisation path through communicating NEs via data ports.

The synchronisation is carried by virtue of the synchronisation signal's aggregate bit rate

rather than the data it contains. The signal also carries the synchronisation status message

(SSM).


For brevity in the following the invention will be described with reference to SDH, it

being understood that the invention is also applicable to SONET.  A significant feature

of SDH systems is the ability of networks to automatically recover from synchronisation

failures. To support this feature each SE requires a pre-configured synchronisation source

priority table and each synchronisation signal must carry an indication of the quality of

the timing source from which it is derived.  In SDH networks, this indication of quality

is carried in the SSM.  For any one STM-N output, the SE will autonomously select from

the SSM values of the available sources the one with the highest quality. The selection

of which source to use to synchronise data signals sent out from STM-N ports of an SE

is also controlled by the pre-configured priority table of that equipment. For any one

STM-N output, one or a number of synchronisation sources can each be assigned a

priority and the SE can use the priority table to identify the source with the highest

priority. In practice priority is only used to select a synchronisation source if there are

more than one available with the same, highest quality, or if a valid SSM is not available.

At a network level it is important that the overall trail of successive synchronisation

sources (which may be described as a "daisy chain" of SEs passing synchronisation

information from one to the other along the chain) always refers back to a designated

external source. This is illustrated in Figure 1. It is also important that every effort is

made to prevent a timing loop occurring. A timing loop occurs when a synchronisation

signal transmitted by a SE is returned (i.e. looped-back) to the same SE which then

selects that looped-back synchronisation signal as its source for transmitting thus "closing

the loop" such that there is no independent external source of synchronisation. This is

illustrated in Figure 2.

To avoid this situation, international standards (e.g. pr ETS 300 417-6-1) define a method

whereby, when a synchronisation source input to a SE via a particular port is selected for

onward transmission by that SE, the SSM sent out by that particular port is set to "do not

use" (DNU). A synchronisation signal with an associated SSM of DNU will not be used.

This ensures that a synchronisation signal directed back towards the original source of

synchronisation is not itself used for synchronisation.

However, the method of the above International Standard does not cope with the situation where two adjacent NEs are connected via more than one port. Whereas a SSM of DNU will be transmitted on the first port at which the synchronisation signal is received, the second port connected to the same source of synchronisation can still output a synchronisation signal with a valid (i.e. non-DNU) SSM.

The present invention provides a communications system comprising a plurality of interconnected network elements (NE), in which each NE comprises one or more ports, each port for inputting from an adjacent one of the plurality of NEs a synchronisation signal and a quality level indication (QLI) for indicating the quality of the source of the synchronisation signal; each port for outputting to the adjacent NE a selected one of the input synchronisation signals and a QLI; in which each NE is associated with a unique NE identifier; in which each port of each NE is associated with a source identifier (SID) for identifying the port at which each synchronisation signal is input; in which each port of each NE comprises QLI means for setting the value of the QLI output at that port based on a comparison of the SID of that port with the SID of the selected synchronisation signal input port; and in which the SID of each port comprises the NE identifier of the adjacent NE.

The present invention also provides a method for indicating the quality level of synchronisation signals in a communications system comprising a plurality of interconnected network elements (NE), in which each NE comprises one or more ports, each port for inputting from an adjacent one of the plurality of NEs a synchronisation signal and a quality level indication (QLI) for indicating the quality of the source of the

synchronisation signal; each port for outputting to the adjacent NE a selected one of the

input synchronisation signals and a QLI; the method including the steps of allocating to

each NE a unique identifier and allocating to each port of an NE a source identifier (SID)

for identifying the port at which each synchronisation signal is input;   receiving

synchronisation signals at the port or ports of each NE; associating each received

synchronisation signal with the SID of the port at which it is input; selecting for each NE

one of the received synchronisation signals for output from the port or ports of that NE;

comparing the SID associated with the selected synchronisation signal with the SID

associated with each port at which that synchronisation signal is output and setting the

QLI output at each port acording to the result of the relevant comparison; the method

including the step of setting the SID of each port to the NE identifier of the NE to which

that port is directly connected.


Embodiments of the present invention will now be described by way of example with

reference to the drawings in which:-


Figures 1 to 4 show a telecommunications system of the prior art;

Figure 5 shows a telecommunications system according to the present invention.


Before describing the drawings, the various values of SSM will be explained. References

to G.811, G.812 and G.813 relate to respective ITU standards which define the quality

of the original clock from which synchronisation is derived.  ITU Recommendation

G.707 defines SSM values relating to different qualities of original clock.  Five SSM

codes are defined in draft ETS1 recommendation prETS 300 417-6-1 to represent the

synchronisation source quality level, listed in order of decreasing quality level as follows:

−       Code 0010 (Quality PRC) means the synchronisation source is a PRC clock (ETS

        300 462-6, ITU-T Recommendation G.811);

−       Code 0100 (Quality SSU-T), means the synchronisation source is a transit SSU

        clock (ITU-T Recommendation G.812) or a Synchronous Supply Unit (SSU) that

        is defined in ETS 300 462-4;

−       Code 1000 (Quality SSU-L), means the synchronisation source is a SSU clock

        (ITU-T Recommendation G.812);

−       Code 1011 (Quality SEC), means the synchronisation source is a SEC clock (ETS

        300 462-5, option 1 of ITU Recommendation G.813);

−       Code 1111 (Quality DNU), means the synchronisation signal carrying this SSM

        shall not be used for synchronisation because a timing loop situation could result

        if used.


In the Figures numbers in squares denote the priority of sources of synchronisation signal

received at the SE via the STM-N ports, one of which sources is selected by the SE on

the basis of its quality and priority, to provide the synchronisation signal output. As

indicated in Figure 1, the West STM-N input receives a synchronisation signal with a

quality level of G.811 associated with it and is allocated priority 1 as a source of

synchronisation signal. The East STM-N input is allocated Priority 2. In fact, the

synchronisation signal received at the East STM-N port of SE1 has been looped back at

SE2 and this is reflected in the assigned SSM value DNU.


Figure 2 illustrates the problem that can arise with a synchronisation timing loop. In

Figure 2 we see that the synchronisation source arriving at the West port of SE1 has failed and as a result SE1 has switched to its alternative synchronisation input at the East port. However the source of synchronisation signal at the East port has already been looped back in SE2 at its West port from the synchronisation signal previously supplied by SE1. Thus a loop is created without any reference to an external source of synchronisation with a consequent degradation of clock quality. This inferior synchronisation signal is also being propagated by SE2 via its East port with an inappropriately good SSM of G.811.

Figure 3 shows the internal working of a conventional SE in more detail. In Figure 3 each STM-N port $S_1$, $S_2$, . . . . .$S_N$ of the SE comprises a source identity (SID) generator, a DNU controller and an SSM output selector Y. The SID generator provides a unique value identifying the relevant port for accompanying the received synchronisation and SSM signals through the SE. The SID value is also passed to the DNU controller for the same STM-N port.

The selectors (T4) are shown schematically as comprising three, ganged, single-pole, multi-way switches, one switch for each of: the synchronisation signal (Clock), the SSM and the SID. Each switch takes an appropriate input from each of the STM-N ports ($S_1$-$S_N$).The outputs of the T4 selectors are denoted $Clock_{SEL}$, $SSM_{SEL}$, and $SID_{SEL}$, respectively. The ganged selectors in Figure 1 are automatically controlled by the SE. The operator configures the equipment with a number of possible sources (S1, S2, ...$S_N$) and the automatic selection will normally select the source that has the highest quality as determined from its SSM value. However there are, in practice a number of special

modes whereby the selection of the highest quality can be withheld when the quality of

source changes in order to reduce the number of intermittent changes. In practice, the

switching functions, described above would typically be performed in software.

Considering STM-N Port S1: the SSM value and synchronisation signal ($SSM_{S1}$, $Clock_{S1}$)

are derived from the STM-N inputs Rx Clock, Rx SSM and pass to the T4 selectors along

with the locally generated SID value ($SID_{S1}$) unique to that port. The T4 selectors route

the synchronisation signal received from a selected one of the STM-N ports for output

from all of the STM-N ports. This selection process involves distribution of the

synchronisation signal, the SSM and the SID in a ganged manner, i.e. the synchronisation

signal SSM and SID from a single STM-N port are selected together and are then

returned to all of the STM-N ports where the synchronisation signal and SSM are output

from the SE but the SID is terminated at the DNU controller.


The DNU controller compares the SID of signals received from the selectors (SIDsel)

with the SID applied directly from the local SID generator ($SID_{sx}$, where x=1, 2...N). If

the two SID values agree then the signals received from the selectors are the same as

those input to that port from the STM-N link, so in transmitting these same signals back

to the same STM-N link, a loop-back is generated. In order to alert NEs connected to

this STM-N link to this state of affairs, the STM-N port outputs a DNU SSM under

control of the DNU controller. The DNU controller controls the operation of the SSM

output selector Y to output either the SSM value received from the selectors (SSM sel)

or the DNU value, accordingly.


In the example shown in Figure 3, Port $S_1$ will output a Tx SSM of DNU while all other

ports will present a $T_X$ SSM derived from $SSM_{S1}$.

Figure 4 shows a further problem that can arise despite the use of SIDs as described above. The arrangement of Figure 4 differs from that illustrated above in that SE1 and SE2 are now interconnected via two separate ports i.e. SE1 port C to SE2 port A and SE1 port D to SE2 port B).

Whereas the mechanism described above is effective in allocating an SSM of DNU to the synchronisation signal looped back to the port at which it was received (in this case SE2 port A) it does not prevent the synchronisation signal looped back to SE1 via the second port (i.e. SE2 port B)from being allocated an inappropriate SSM (i.e. SSM=G.811). This looped back timing signal is then propagated by SE1 from its west ports with the inappropriate SSM value.

A characteristic of SDH systems is that, for the purposes of network planning and overall control, each network equipment is allocated a unique identification (NEID). The NEID allocated to each node is centrally stored at a network control function which acts to control all the SEs in the telecommunications network. The central network control function uses the NEID to address specific nodes, e.g. for configuring the SE or obtaining status information therefrom. By "central" is meant a single entity servicing a network, as opposed to each NE acting independently. The actual location of such an entity is not defined. According to the present invention the conventional SID value allocated to each port of an SE is replaced by the NEID value corresponding to the SE to which that port is directly connected. This automatically copes with the situation where more than one

port on any particular SE is directly connected to the same source/destination SE. When

combined with the above described system for checking SIDs at output ports in order to

detect looping back of synchronisation signals, the present invention advantageously

prevents the looping back of synchronisation signals received from a second SE to the

same second SE without that synchronisation signal being correctly identified with an

SSM of DNU.

Allocation of SID values is currently effected manually based on SE connectivity data

relating to the telecommunications network. This manual activity is tedious and prone

to error. The replacement of the current SID values with values incorporating the NEID

of the connected SE advantageously reduces the scope for error by making the correct

SID more easily identifiable to the operator.

In a preferred embodiment of the present invention, the SID value of each port is

automatically set-up by the central network control function on the basis of the NEID

information and the connectivity information already contained in that function. This

may be simply achieved by arranging for the central network control function to send a

control message to each SE containing instructions regarding the setting of the various

SIDs for each port.

To be precise, these SIDs should now be referred to as destination identifiers (DIDs) as

they determine the destination to which the synchronisation signal output at that port is

directed.

In a further preferred embodiment of the present invention each network equipment is programmed on initialisation to send a message containing its own NEID to each adjacent network equipment. Each SE is also programmed, on receiving the "NEID" message from its adjacent SEs to set the values of the SIDs of its ports to the NEID value contained in the message received at that port.

In a further preferred embodiment, the SEs repeatedly send NEID messages to adjacent SEs e.g. as a background or a regularly scheduled task, thus advantageously allowing for any changes in the topology of the network to be automatically reflected in the SID allocation of the SEs affected.

Figure 5 shows application of the invention to a complex network in which multitude of SEs are interconnected. Each SE in Figure 5 is identified by its NEID which, as is normally in the case, consists of a name that is usually derived from the geographical location of the SE. The central SE comprises 7 ports $P_1$ to $P_7$, each port is connected to a further SE and, in particular ports $P_6$ and $P_7$ are both directly connected to SE "New Port". Each of the SEs connected to SE "Central" has further ports for connection with other SEs (not shown). According to the invention both the ports of SE "New Port" that are directly connected to SE "Central" are given the SID "Central". As a result, if the synchronisation signal selected by SE "New Port" is from one of the ports connected to SE "Central", this synchronisation signal is sent out of both ports connected to SE "Central" with an SSM of DNU.

Although the above embodiments have been described with reference to SDH equipment

the same techniques are equally applicable to other synchronous communications systems

notably SONET systems.

## CLAIMS

1.  A communications system comprising a plurality of interconnected network

    elements (NE), in which each NE comprises one or more ports, each port for

    inputting from an adjacent one of the plurality of NEs a synchronisation signal

    and a quality level indication (QLI) for indicating the quality of the source of the

    synchronisation signal;

    each port for outputting to the adjacent NE a selected one of the input

    synchronisation signals and a QLI;

    in which each NE is associated with a unique NE identifier;

    in which each port of each NE is associated with a source identifier (SID) for

    identifying the port at which each synchronisation signal is input;

    in which each port of each NE comprises QLI means for setting the value of the

    QLI output at that port based on a comparison of the SID of that port with the SID

    of the selected synchronisation signal input port;

    and in which the SID of each port comprises the NE identifier of the adjacent NE.

2.  The system as claimed in Claim 1 also comprising a central management means,

    in which the management means comprises means for setting the SID of each port

    of each NE to the appropriate NE identifier value.

3.    The system as claimed in Claim 1 in which each NE comprises sending means for

      sending its own NE identifier to each NE to which it is directly connected.


4.    The system as claimed in Claim 3 in which the sending means is arranged to

      repeatedly send the NE identifier.


5.    A method for indicating the quality level of synchronisation signals in a

      communications system comprising a plurality of interconnected network

      elements (NE), in which each NE comprises one or more ports, each port for

      inputting from an adjacent one of the plurality of NEs a synchronisation signal

      and a quality level indication (QLI) for indicating the quality of the source of the

      synchronisation signal.


      each port for outputting to the adjacent NE a selected one of the input

      synchronisation signals and a QLI;


      the method including the steps of allocating to each NE a unique identifier and

      allocating to each port of an NE a source identifier (SID) for identifying the port

      at which each synchronisation signal is input;  receiving synchronisation signals

      at the port or ports of each NE;  associating each received synchronisation signal

      with the SID of the port at which it is input;  selecting for each NE one of the

      received synchronisation signals for output from the port or ports of that NE;

      comparing the SID associated with the selected synchronisation signal with the

      SID associated with each port at which that synchronisation signal is output and

setting the QLI output at each port acording to the result of the relevant comparison;

the method including the step of setting the SID of each port to the NE identifier of the NE to which that port is directly connected.

6.    The method as claimed in Claim 5 in which the communications system also comprises a central management means; the method including the step of operating the management means to associate each port with the appropriate NE identifier value.

7.    The method as claimed in Claim 5 including the step of each NE sending its own NE identifier to each NE to which it is directly connected.

8.    The method as claimed in Claim 7 including the step of each NE repeatedly sending the NE identifier.

9.    A communications system substantially as described with reference to and as illustrated in Figure 5 of the drawings.

10.   A method of indicating the quality level of synchronisation signals in a communications system substantially as described with reference to and as illustrated in Figure 5 of the drawings.

# ABSTRACT

In a synchronous digital communications system a network of SDH (or SONET) equipments (SE) are arranged to exchange synchronisation signals via ports on the SEs, each port being allocated a source identifier (SID). These SIDs are used to identify the source of each synchronisation signal input at a particular SE. When the SE selects a synchronisation signal to transmit out of its ports, the SID associated with that selected signal is compared with the SID of each port. If a match is found the synchronisation status message (SSM) associated with the synchronisation signal sent out at that port is set to "Do Not Use" (DNU) to warn the destination SE that the synchronisation signal has been looped back. Each SE is allocated a unique equipment identifier. The SID of each port is set to the unique SE identifier of the SE to which it is directly connected.

SSM=0010 (G.811) | 1 | SE 1
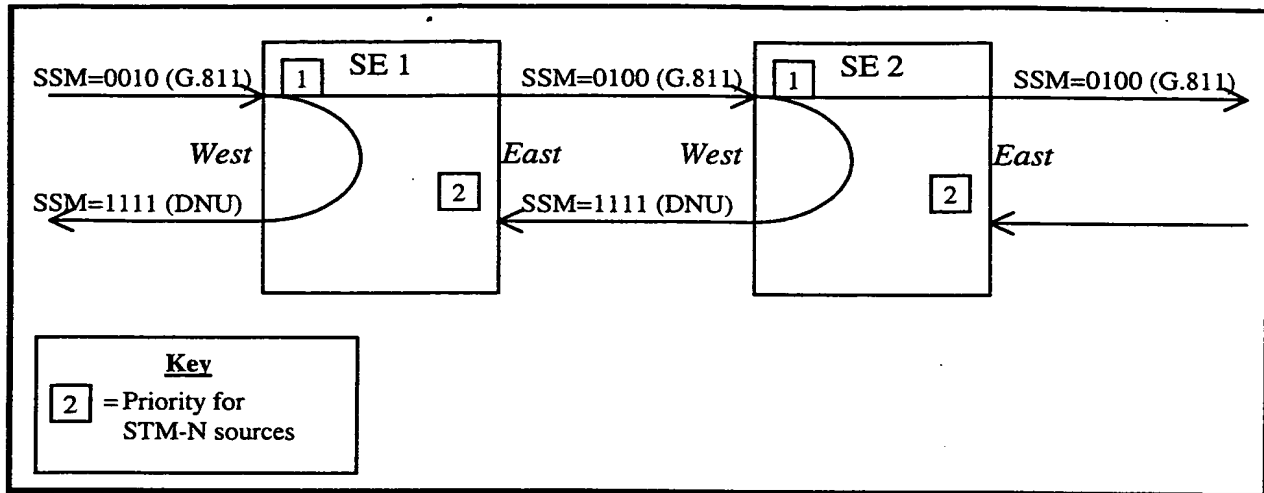
SSM=0100 (G.811) | 1 | SE 2

SSM=0100 (G.811)

West

East

West

East

2

2

SSM=1111 (DNU)

SSM=1111 (DNU)

**Key**

2 = Priority for STM-N sources

Figure 1      Timing Loop Prevention

*Failed* | 1 | SE 1

1 | SE 2

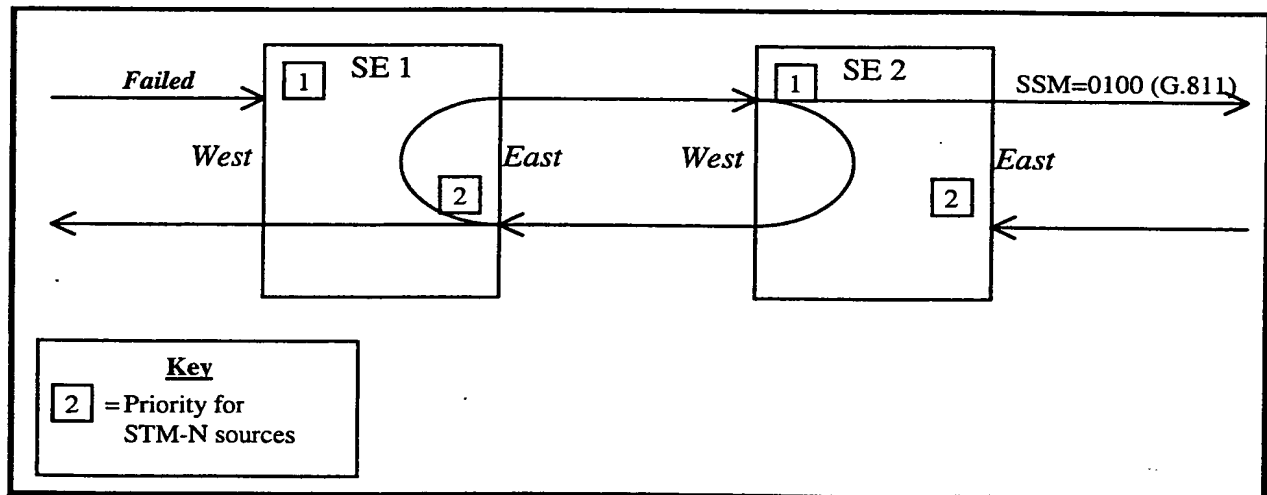SSM=0100 (G.811)

West

East

West

East

2

2

**Key**

2 = Priority for STM-N sources

Figure 2      Synchronisation Timing Loop

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Figure 3     General use of SID in Timing Loop Prevention

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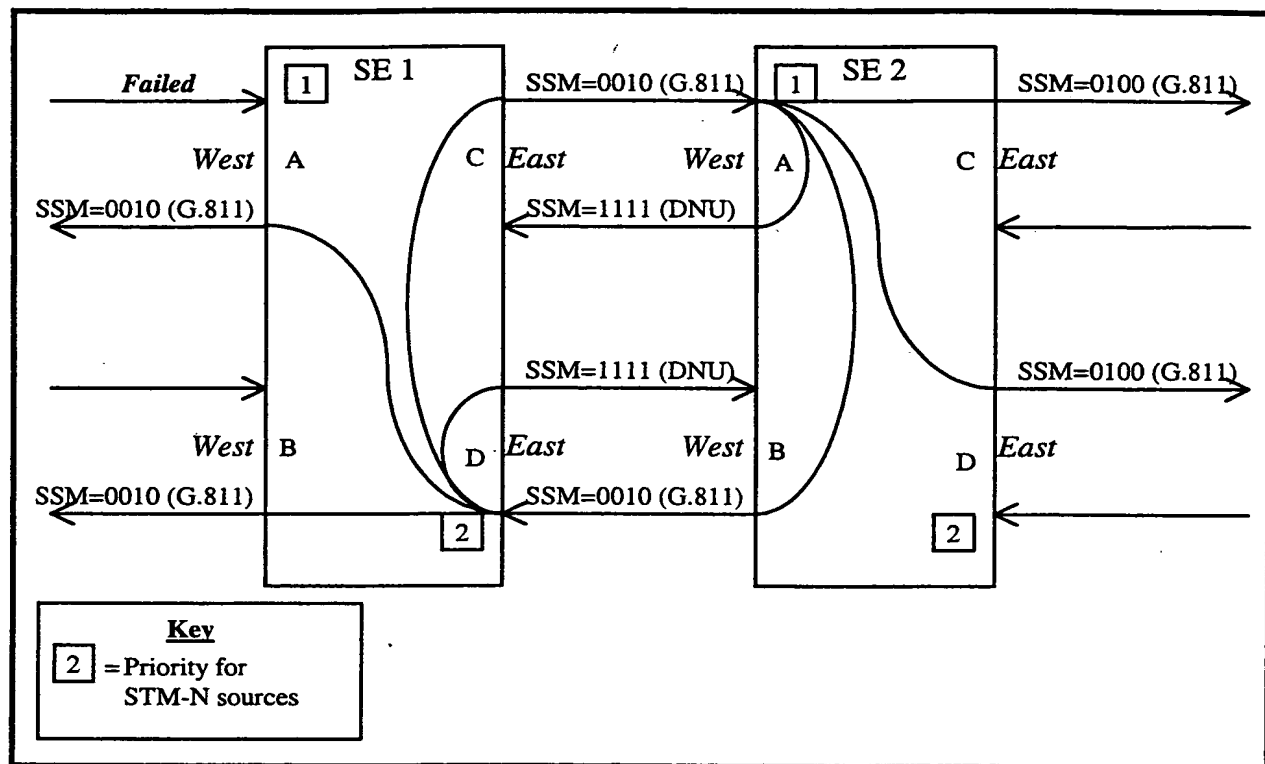
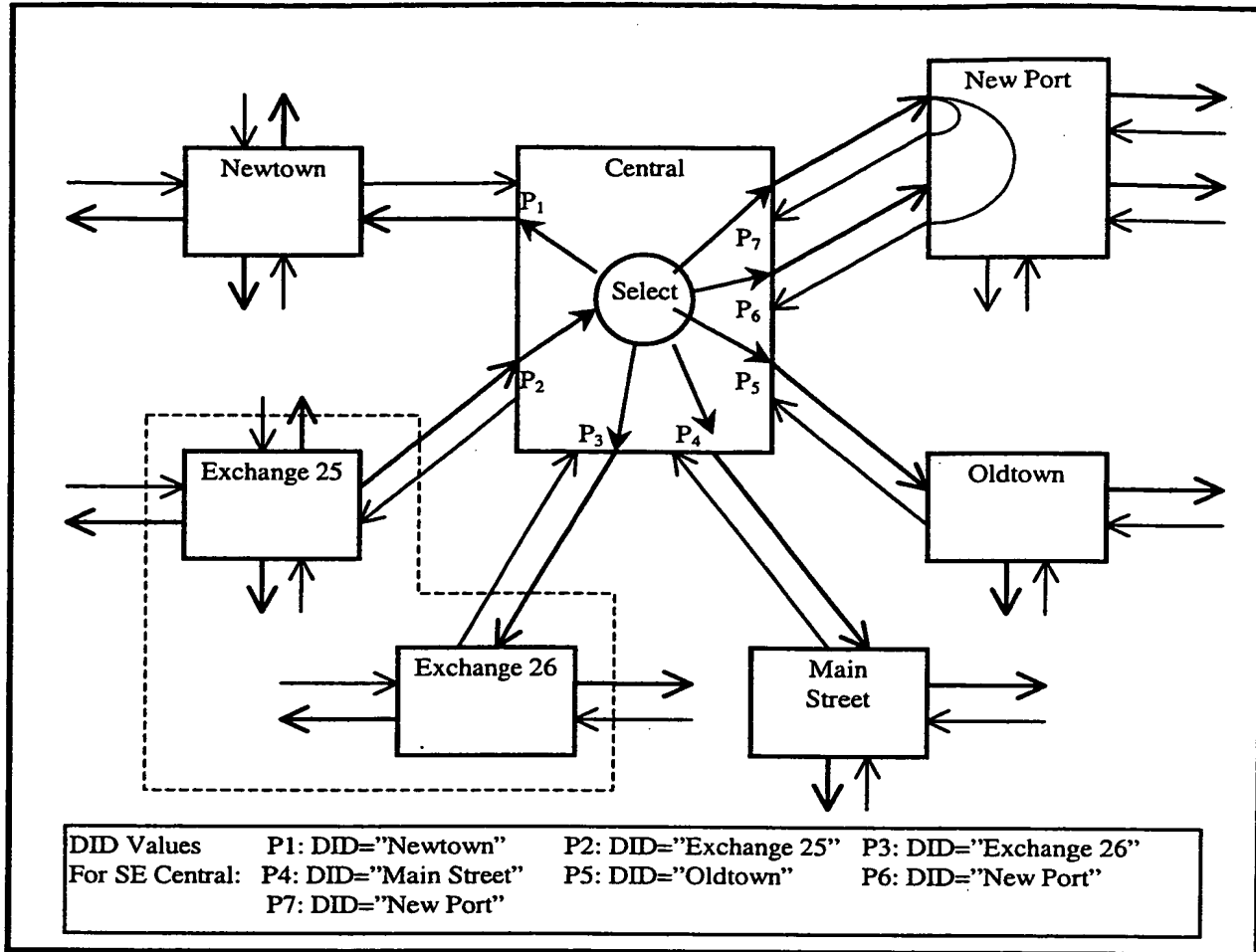Figure 4     Multiple Port Timing Loop

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Figure 5     Destination IDs